HUMAN MOVEMENT
2017; 18(3): 3–11

PHYSICAL ACTIVITY LEVEL HAS A GREAT INFLUENCE ON THE NUTRITIONAL STATUS OF ADOLESCENTS: A REVIEW ARTICLE

review article
doi: 10.1515/humo-2017-0024

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ABSTRACT
Purpose. The aim of the review was to investigate the relationship between physical activity level (PAL) and nutritional status (NS) in adolescents.
Methods. Seven electronic databases were searched for research from the years 2005–2015. The studies must have mentioned the relationship between PAL and NS parameters in adolescents. After the review of abstracts and articles, 22 papers meeting the required criteria were further analysed in detail.
Results. The studies included 31,045 subjects of both sexes. The results showed that smaller PAL led to an increase of NS parameters and vice versa. Comparing the total PAL, the total time spent in moderately vigorous physical activity, and the total time of vigorous PA (VPA), only VPA was a significant predictor of the responders' percentage of fat mass. Reducing the activity by 10 MET on the weekly level was associated with an increase in BMI in girls for 0.11 kg/m^2, while an increase of the activity by 1 hour per week resulted in a decline in BMI by 0.13 kg/m^2.
Conclusions. Total PAL has a significant correlation with NS in adolescents. This relationship is inverse, which means that more active adolescents are less overweight than their less active and/or inactive counterparts and vice versa. In addition to PAL, the character or intensity of physical activity has a significant impact on BMI. Physical activity of higher intensity influenced the reduction of body weight and fat mass more than activity of the same duration but of moderate intensity.
Key words: inactivity, body mass index, body composition, obesity, children

Introduction

Over half a century ago, Mayer [1] recorded the role of physical activity (PA) in the aetiology of obesity. It has long been speculated that hypokinesia may have a greater role in the development of obesity than diet [2]. Low PA levels (PAL) and the widely observed sedentary behaviour are characterized as the main causes of obesity and are essentially referred to in the World Health Organization recommendations. Accordingly, increasing PAL on a daily basis and reducing sedentary habits in general are the key steps for obesity prevention that do not involve diet [3, 4].

Consequently, many organizations around the world, especially in America, have begun to recommend the appropriate PAL for modern humans, including children of school age [5]. Despite all the health benefits of PA, people worldwide do not practise it in suitable amounts [6]. An even greater problem is that children are less involved in any form of regular PA today [4, 7], which might by influenced by environmental factors [8] and lifestyle [9, 10]. Several previous studies suggested a benefit of regular PA on the health of young people and their potential to reduce the incidence of chronic diseases in adulthood [4, 11–13].

Recently collected data suggest a dramatic increase in obese children and adolescents in the past two decades [4, 14, 15]. According to the estimates provided by the NHANES III survey, approximately 10.9% and 22% of children and adolescents, respectively, are overweight (between 85th and 95th percentiles). Substantial increases in overweight occurred among all age and ethnical groups, in both sexes [15, 16]. The manifestation of short- and long-term morbidity caused by obesity increases the need for understanding this phenomenon as a major public health problem in children and adolescents [17].

PA has a positive impact on the health status of children and adolescents [18]. Thus, it can be assumed that a higher PAL brings a greater benefit for the body composition and health status of young people as well. Therefore, the aim of the study was to critically review the literature and investigate the influence of PAL on the

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Received: October 23, 2016
Acepted for publication: July 18, 2017

Citation: Paravlić A. Physical activity level has a great influence on the nutritional status of adolescents: a review article. Hum Mov. 2017;18(3):3–11; doi: 10.1515/humo-2017-0024.

nutritional status of adolescents. Another aim was to define optimal qualitative and quantitative PA characteristics for proper prevention of obesity and/or reduction of excessive weight.

Literature search

Definition of terms

The most frequently applied definition of PA is that of World Health Organization, where PA is referred to as 'any bodily movement produced by skeletal muscles that requires energy expenditure' [19]. PA is described with four different dimensions: frequency (number of trainings per a unit of time), intensity (level of energy expenditure adopted to body mass), time, and type, which represents the qualitative character of the activity [20]. Body composition is often presented as the comparison between lean body mass (LBM) and body fat mass (FM) [21], and it plays an important role in sport and health [22].

Overweight and obesity are defined as abnormal or excessive fat accumulation that presents a risk to health [23]. 'Body mass index (BMI) is a simple index of weight-for-height that is commonly used to classify overweight and obesity in adults. It is defined as a person's weight in kilograms divided by the square of his height in meters (kg/m^2)' [24]. BMI is equally used for both genders and all categories of adults [24], while adopted parameters are applied for children, where cut-off points are defined as follows: overweight: > +1 *SD* (equivalent to BMI 25 kg/m^2 at 19 years); obesity: > +2 *SD* (equivalent to BMI 30 kg/m^2 at 19 years); thinness: < –2 *SD*; and severe thinness: < –3 *SD*. These values should be considered a rough guide because they may not correspond to the same degree of fatness in different individuals [24].

Berk defined adolescence as a period of human growth and development, which could be divided into three age categories [25]: early, middle, and late adolescence, occurring between 11 and 14, 14 and 18, and 18 and 21 years of age, respectively.

Search strategy

The following electronic databases were searched for the collection of articles investigating the influence of PAL on the nutritional status of adolescents: PubMed/Medline, Pedro, SPONET, Science Direct, Google Scholar, ERIC, and DOAJ. Papers that were taken into consideration were published in the period of 2005–2015. In the database search, we used the following keywords and combinations of those: *physical activity*, *body composition*, *body fat percentage*, *weight*, *BMI*, *obesity*, *adiposity*, *anthropometric measurements*, *skinfold thicknesses*, *influence*, *relationship*, *adolescents*.

Inclusion of studies

Founded research topics, abstracts, and full texts were read and analysed. For final analysis, we accepted research that met the following criteria: (a) the article was published in the period between 2005 and 2015; (b) the subjects were in their adolescence (i.e., between 11 and 21 years of age); (c) the main outcome measures included the anthropological status of the responders or measures of body composition as a parameter of nutritional status (fat-free mass [FFM]; FM; BMI), and/or PAL as well.

Studies that met the established criteria were analysed and presented on the basis of the following parameters: reference (i.e., author's name, year of research publication); study design; subjects' data (i.e., sample number, gender, and age); classification of participants by groups; treatment – if there was any (e.g., duration and type; education about healthy lifestyles and the importance of PA); outcome variables – evaluation of PAL, nutritional status; and research results (Table 1).

Results and discussion

The process of collecting, analysing, and eliminating papers is displayed in Figure 1.

Throughout electronic database search, 3240 papers were identified. The number of articles that were immediately excluded on the basis of the title and duplicates was 2756, while 484 papers were included in further analysis. Further analyses excluded 462 papers on the basis of several criteria: (a) abstract; (b) being review articles; (c) inadequate age of participants; (d) variables for monitoring the influence of PAL on the nutritional status being not implied measures of body composition. Out of all the examined papers, 22 met the set criteria: (a) the responders were in their adoles-

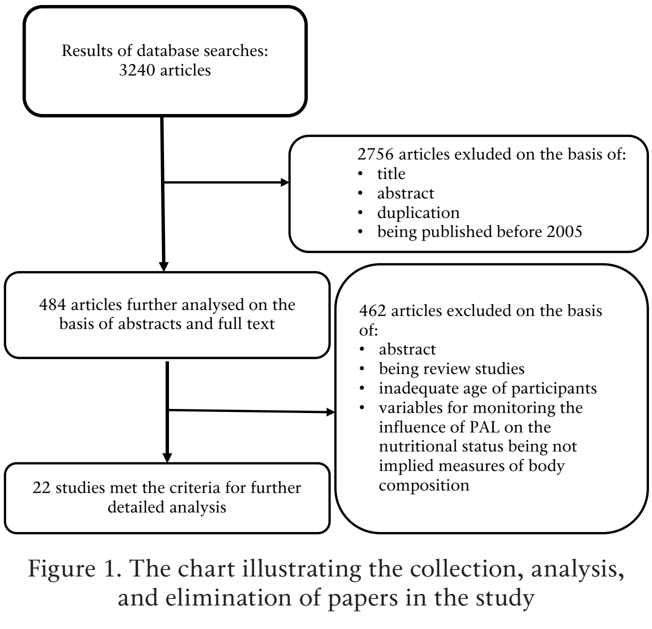

Figure 1. The chart illustrating the collection, analysis, and elimination of papers in the study

cence; (b) the study had a cross-sectional design, and (c) the research employed measurements of the anthropological status of the subjects, and/or measures of body composition as a parameter of nutritional status (FFM, FM, BMI), and/or PAL.

Studies that met the inclusion criteria were then analysed and represented on the basis of parameters that are listed in the 'Inclusion of studies' section.

The majority of the analysed studies were cross-sectional. Only in 3 articles, a partly experimental nature of the study design can be found [26–28]. Treatment in the form of education about healthy lifestyle was carried out in one of the aforementioned studies; it was characterized by involving breaks for physical exercise and eating healthy meals during ordinary school hours [26]. The second one employed similar treatment, defined as a strategy for reducing obesity in the adolescent period called PRALIMAP [27]. In the third partly experimental study, the researchers included professional counselling directed towards lifestyle changes and mandatory visits to nutritionists once per week in combination with two times weekly PA bouts of 60 minutes each [28].

The total of 31,045 subjects participated in the analysed studies. The largest number of responders, 9155, were included in the study of Boone et al. [33], while the smallest, i.e. 42, referred to the study of Ara et al. [36]. Both sexes were equally distributed in most of the studies; in one, only females were engaged [32]. Ara et al. [36] included only male population, while in two studies [26, 40] gender was not used as a variable of interest.

In several studies, race or ethnicity of the responders was listed as a categorical variable [29, 32, 33, 35, 38, 43, 44, 46]. The direct relationship between race and PAL was investigated in only one study [32], where it was concluded that there was a difference in PAL in relation to ethnicity, i.e. that Afro-American girls represented lower PAL and increased susceptibility to weight gain compared with white girls, which coincides with the results of earlier studies [48, 49].

To assess the level and intensity of PA, researchers used different equipment, like accelerometers [29, 31, 35, 37, 38] or pedometers [30], objectively measuring PAL, or less objective measures, like questionnaires [32, 38–40, 43, 45–47]. The system of calculating calorie consumption by the metabolic equivalent of task (METs), derived by questionnaires, was applied in two studies [31, 32].

In many of the analysed studies, the participants were divided into groups according to the degree of nutritional status based on BMI. Thus, the categorization of subjects was as follows: (a) normal weight (including underweight subjects); (b) overweight; (c) obese. Only the study of Elgar et al. [47] aimed to investigate the correlation between PAL and nutritional status in the underweight group (i.e., BMI ≤ -2 *SD*, or BMI ≤ 20 kg/m^2) of adolescents, analysing them separately from other weight categories. In the study [47], the authors came to the conclusion that underweight children had the lowest PAL as compared with other groups.

During the period of adolescence, PAL is inversely related to age, recording a significant drop with increasing age [29, 32]; this phenomenon was discussed elsewhere [6, 50–53].

Cross-sectional data revealed meaningful differences in PAL between sexes: boys practised more PA per day [29, 31, 41, 43, 46]. However, Guilherme et al. [39] failed to show the same trends. This discrepancies in the observed results might be influenced mainly by the methodological approach (type of PAL assessment tool, mean age of the responders, ethnicity of the included subjects, their habits, etc.) [8, 9, 29, 32].

Many studies have proven the hypothesis that lower PAL causes overweight and leads to an increase in the parameters of body composition and vice versa [26, 31–33, 37, 41, 42, 44–47], while one study did not record significant differences in the body composition in relation to PAL [30]. In two studies [34, 36], active boys had higher BMI values, but in all parameters of functional abilities they were superior compared with the inactive group. The authors explain this increase in BMI in favour of LBM, as a result of increased PA during growth and development [54, 55]. The data obtained in this study indicate that additional extracurricular activities for at least 2 hours a week can be a protective factor of accumulating subcutaneous fat that can improve the physical fitness of adolescents. Also, the use of BMI as an index of obesity can lead to incorrect assumptions when the physical status of active children, especially boys, is concerned [34]. It is important to note that the active subjects had lower percentage of FM (%FM) and that %FM was held on the same level during the period of 40 months, while these values increased in inactive subjects [36]. In other studies, similar results were achieved after a certain period of follow up [27, 28, 34, 43, 44, 46].

PA at higher intensities has a more meaningful impact on the reduction of FM [35, 43] compared with activity of moderate intensity. Some earlier studies have confirmed this paradigm but the problem of including obese subjects in higher PA programs arose from the inability of obese participants to maintain activity of high intensity for a longer period of time [56]. Comparing the overall PAL, the total time spent on moderately vigorous PA (MVPA) and the total time of vigorous PA (VPA), only VPA was inversely correlated ($R^2 = -0.335$; $p = 0.003$) with the responders' %FM [35].

Decreasing the activity by 10 METs on a weekly basis is associated with an increase in BMI ($p < 0.001$) by 0.14 and 0.09 kg/m^2 for black and white girls, respectively [32]. These results suggest that habits regarding PA play an important role in the control and/or increase of body weight [4], while there are no parallel results indicating that calorie intake has a similar role [32].

Table 1. The systematic review and characteristics of the included studies

Reference	Study design	Participants	Groups	Treatment	Evaluation of PAL and nutritional status	Results
Troiano et al. [29]	CSS	N: 1181 B: 570 G: 611 Age: 12–19 USA	Based on sex, race, and age	No	Nutritional status (BMI) PAL (accelerometer)	– Adolescents were less active than younger ones, regardless of sex – No differences in PAL between races, but there were some based on sex – PA intensity and volume decreased significantly through the years – Mean values of BMI in older adolescents were higher than in younger ones
Hands and Parker [30]	CSS	N: 1539 B: 787 G: 752 Age: 7–16 USA	Based on BMI: 1. Overweight 2. Obese 3. Normal weight	No	Nutritional status (BMI and WC) PAL (pedometer)	– Considerable correlation between BMI and WC – No significant correlations between BMI and PAL with regard to sex – Not significant relation between WC and PAL
Colley et al. [31]	CSS	N: 1608 B: 809 G: 799 Age: 6–19 Canada	Based on PAL: 1. Sedentary 2. Less active 3. Moderately active 4. Most active	No	Nutritional status (BMI) PAL (accelerometer) Energy expenditure (METs)	– Most children led sedentary lifestyle – Obese and overweight children had less accumulated PA than normal weight children – Obese boys were less active than obese girls – Between 11 and 19 years of age, boys were more active than girls
Kimm et al. [32]	CSLS	N: 2287 Black G: 1152 White G: 1135 Age: 9–19 USA	Based on race and PAL: 1. Sedentary 2. Moderately active 3. Active	Measurements in 3rd, 5th, 7th, and 10th year of study	Nutritional status (BMI, SF, DEI) PAL (HAQ, METs)	– Black girls were heavier in adolescence than white girls – In the black group, caloric intake increased with time, while in white girls it stayed on the same level – 58% inactive subjects of black girls stayed inactive, compared with 11% of the white girls group – BMI increased with age, but with significant differences in inactive subjects compared with others PAL groups – In groups that maintained active lifestyle, the increase of BMI and SF was smaller than in the less active groups
Boone et al. [33]	CSLS	N: 9155 B: 4879 G: 4276 Age: 13–26 USA	Based on sex and age: Wave 1: 13–20 Wave 2: 19–26	Followed up for 6 months	Nutritional status (BMI) PA (MVPA and ST)	– % of obese in both sexes doubled with age – Normal weight subjects from both groups were more active and had less TV time than obese ones – In both sexes, obese impairment was noted in younger adult age if there had been no increase in PAL in adolescence
Grydeland et al. [26]	CSLS	N: 1324 Age: 11 Norway	Base on intervention: EXP-784 CON-1381	20 months of healthy lifestyle education plus healthy meals and PA	Nutritional status (BMI, WHR) SES (QFS and PE)	– No significant difference in nutritional status between groups after treatment – A significant difference between groups with regard to gender; girls from EXP had lower increase in BMI than those from CON – Children of parents with higher education level had a lower increase of BMI over time
Ara et al. [34]	CSS	N: 1068 B: 558 G: 510 Age: 7–12 Spain	Active group: 681 (B: 374, G: 307) Inactive group: 387 (B: 184, G: 203)	No	Anthropometry (BMI, SF) Fitness components (VO_2max, hand grip strength, pull up folding endurance, velocity of hand tapping, running speed – 5 and 10 meters – shuttle run, flexibility)	– No difference in BMI between rural and city children – Boys from the active group had slightly higher body weight and were more obese by BMI compared with the inactive group, but had lower SF values and better fitness test results – Active girls had lower BMI and SF values than sedentary ones – Active girls had better results in all fitness tests, except for hand grip strength and hand tapping test, compared with inactive group – It was concluded that PAL had very strong influence on BMI and SF in boys but not in girls – VO_2max was negatively correlated with obesity

Gutin et al. [35]	CSS	N: 421 B: 196 G: 225 Mean age: 16 USA	Based on race (white/black) and gender (B/G)	No	Nutritional status (%FM) PA (accelerometer) Fitness components (CVF)	– Higher CVF index was positively correlated with higher PA – More variables positively correlated with higher PA than with moderate PA – PA of higher intensity had a greater influence on %FM than PA of moderate intensity
Ara et al. [36]	CSLS	N: 42 B: 42 Age: 8–14 Spain	Based on age and PAL: 1: 9.4 2: 12 1. Active group 2. Inactive group	Followed up for 40 months	BC Anthropometry (body circumferences and SF) Fitness components (dynamic force, isometric force, anaerobic capacity, regional FM, maximal aerobic power, and MAP)	– Greater increase of BMI in the active group than in the inactive one – Accumulation of FM over years was lower in the active group – Positive correlation noted for both body weight and FM, more pronounced in the inactive group – Inverse relationship between increase in LBM and total body fat and/or regionally distributed body fat – Physical conditions stayed the same in the active group, decreased in the inactive group
Martinez-Gomez et al. [37]	CSS	N: 2094 B: 973 G: 1121 Mean age: 14.7 EU	Based on nutritional status and gender	Data collected from 2006 to 2007	PAL Nutritional status (BMI, %FM, SF)	– ROC analyses indicated a great influence of PAL on BMI – Adolescents without enough daily activity level, as prescribed by WHO (60 min/day MVPA), significantly increased their obesity risk
Bonsergent et al. [27]	CSLS	N: 3538 B: 1499 G: 2039 Mean age: 15.6 France	1. Schools with strategy 2. Schools without strategy	PRALIMAP: healthy lifestyle education plus breaks for activity and consumption of healthy meals	Nutritional status (BMI)	– Adolescents who finished the program had lower incidence of eating disorders and depression – They came from the upper class – Adolescents form schools with strategy had better BMI results
Liu et al. [38]	CSS	N: 1978 B: 932 G: 1046 Mean age: 16.5 Twins; USA	Based on ethnicity: 1. European origin Americans (N: 953) 2. Afro-Americans (N: 1025)	No	Nutritional status (%FM, VAT, SAAT, WC, SF, DEI) PAL FTO rs9939609	– VPA was negatively correlated with SF, %FM, SAAT, but not with BMI, WC, or VAT; energy intake was a negative determinant for BMI, SF, VAT, and SAAT – FTO rs9939609 was significantly correlated with BMI ($p < 0.01$), body weight ($p < 0.03$), and WC ($p < 0.04$)
Guilherme et al. [39]	CSS	N: 566 B: 287 G: 279 Mean age: 12.4 Brazil	Based on gender and type of school (public or private)	No	PAL (questionnaire) Nutritional status – anthropometry (BMI, WC) Prevalence of obesity, factor influencing PA decrease	– No significant differences in PAL with regard to gender – Strong correlation between PAL and BMI, WC, with prevalence for adolescent obesity ($p < 0.001$) – High influence of physical inactivity on obesity (*OR*: 1.8, 95% CI: 1.1–3.0) and WC (*OR*: 2.8, 95% CI: 1.4–3.8) – The most inactive were boys aged 10–12 attending public schools – Students classified as higher BMI and WC had 1.8 and 2.2 times lower PAL, respectively, compared with peers with normal values of these measures
Abu-Kishk et al. [28]	CSLS	N: 44 B: 28 G: 16 Age: 12–18 Israel	Based on nutritional status: 1. Obese 2. Normal weight and: EXP-36 CON-8	6 months of intervention: counselling about lifestyle change (meeting with a nutritionist once a week and physical training 2 × per week for 60 minutes)	BMI, arterial stiffness, blood pressure, pulse, body weight, haemo-globin, creatinine, CRP, liver enzymes, lipids in blood	– 21 subjects (50%) finished the study – Little level of parental consent for this type of intervention – After treatment, BMI decreased from 32.46 ± 3.93 kg/m^2 to 30.32 ± 3.4 kg/m^2 ($p = 0.002$) – Arterial stiffness significantly decreased, while CRP and lipids stayed on the same level

Staiano et al. [40]	CSS	N: 369 Age: 5–18 USA	Based on TV presence in room and daily TV watching time	No	Questionnaires (NHANES) Nutritional status (BMI, WC, VATm, %FM), triglycerides, ECMR	– The presence of TV in the bedroom and total TV watching time were related ($p < 0.05$) with higher values of WC (*OR*: 1.9–2.1), %FM (*OR*: 2.0–2.5), and subcutaneous obesity (*OR*: 2.1–2.9) – Watching TV ≥ 5 h/day was associated with high levels of visceral obesity (*OR*: 2.0) – The presence of TV in the room was associated with ECMR (*OR*: 2.9) and high values of triglycerides (*OR*: 2.0)
Jeddi et al. [41]	CSS	N: 472 B: 238 G: 234 Age: 9–18 Iran	Based on PAL and nutritional status	No	PAL Nutritional status (%FM [DEXA], FMI, FFMI, BMI, WC	– 52.1% of boys had PA 3 times weekly, compared with 9.8% of all interviewed girls – Boys with higher PAL had higher %FFMI than the less active ones ($p = 0.001$) – The more active group had lower level of %FM than the less active one – No significant difference related to PAL in girls
Larouche et al. [42]	CSS	N: 1016 B: 520 G: 496 Age: 12–19 Canada	Based on gender and type of activity: 1. Walking (1–5 h, > 5 h, < 1 h) or 2. Riding a bicycle (< 1 h, ≥ 1 h)	No	Fitness (PAL, VO_2max, flexibility [sit and reach test], grip strength) Nutritional status (BMI, WC, SF) Blood pressure and blood samples (HDL, LDL, glucose, HbA1c)	– Adolescents who reported walking for 1–5 h/week had lower levels of WC, HDL, and HbA1c than those who walked less than 1 hour weekly – Those who reported more than 5 h/week walking had greater grip strength and lower values of LDL and HDL – Compared with adolescents who did not ride a bicycle, riders had better aerobic fitness, as well as lower BMI, WC, and HDL values
Fulton et al. [43]	CSSL	N: 472 B: 227 G: 245 Age: 10–18 USA	Based on gender and age: Cohort 1: 8 years Cohort 2: 11 years Cohort 3: 14 years Based on gender: white, black, others	Followed up for 48 months; measurements every 4 months	MVPA (questionnaire) DEI (kcal/day) Sexual maturation, BMI, %FM, FFMI, FMI	– Boys were more active than girls of same age – BMI was lower in Cohort 1 than in Cohort 3, but the lowest in Cohort 2 – BMI and FMI negatively correlated with PA – MVPA was inversely correlated with BMI – Each MVPA increase by 100 min resulted in BMI decrease by 0.23 kg/m^2 in adolescents aged 10–18 – Gender or ethnicity did not influence these data
Steffen et al. [44]	CSS	N: 526 B: 256 G: 270 Age: 8–11–14 USA	Based on gender and ethnicity: black and others	Project duration: 48 months	Parental weight status, TV watching, BMI, FFM, %FM	– Children who had one or both overweight parents watched TV for 22 and 33 minutes longer ($p < 0.001$), respectively, than children whose parents had normal weight – BMI and %FM were increased ($p < 0.001$) by 0.42 kg/m^2 and 1.14%, respectively, with each additional hour of TV watching, but the trend was not shown in children whose parents had normal body weight
Day et al. [45]	CSS	N: 556 B: 277 G: 279 Age: 8–11–14 USA	Based on gender, age, MVPA (min/day), and daily fat intake	Project duration: 36 months	DFI, TV watching, PA, sexual maturation, blood pressure, WC, blood lipids	– Girls with a high fat intake diet had significantly lower PAL than those with a lower fat diet – Comparing fat intake, there was no difference between boys in relation to PAL, blood pressure, WC, or cholesterol – DEI was not different between the groups in relation to the MVPA level – No difference in BMI with regard to DFI or MVPA in both genders – In girls, WC was significantly different depending on DFI; significant difference were also noted for blood pressure relative to DFI and MVPA level

Teo et al. [46]	CSS	N: 454 B: 204 G: 250 Age: 12–19 Malaysia	Based on gender, ethnicity (Malaysian, Chinese), and PAL	No	PAQ, FSQ, BMI, WC, %FM, AFM, DEI, WHR, sexual maturation, SBP	– Boys had more PA ($p < 0.01$) and MVPA ($p < 0.001$) than girls – As expected, boys had higher values of body weight, height, WC, WHR, and DEI – Girls had higher values of %FM ($p < 0.001$) – Boys with less MVPA had higher %FM ($p = 0.006$) and AFM ($p = 0.005$) than boys with more MVPA – Boys with higher PAL (≥ 1.5 h/day) had significantly lower %FM than their less active peers – Girls with higher SBP (≥ 3.5 h/day) had significantly higher BMI ($p < 0.05$), WC ($p < 0.05$), %FM ($p < 0.01$), and AFM ($p < 0.05$) – Boys with total PA < 1.5 h/day had significantly higher obesity odds risk (*OR*: 3.0, 95% CI: 1.1–8.1, $p < 0.05$) than their more active peers – Comparable results referred to MVPA, where less active boys had 4 times higher risk to become obese (*OR*: 3.8, 95% CI: 1.4–10.1, $p < 0.01$)
Elgar et al. [47]	CSS	N: 355 B: NR G: NR Mean age: 12.3 Wales	Based on gender and nutritional status	Measurements at baseline and after 4 years	PAL (PAQ), BMI, SES, EH	– BMI decreased by 0.13 kg/m^2 for every additional hour of PA on weekly basis – Children who had less PA showed tendency for gaining body weight and risk of obesity in adulthood – Obese children had the habits of consuming snacks and skipping breakfast – Underweight children skipped breakfast at least once per week and had lower PAL than the other groups, even the obese

AFM – android fat mass, B – boys, BC – body composition, BMI – body mass index, CRP – C-reactive protein, CSLS – cross-sectional longitudinal study, CSS – cross-sectional study, CVF – cardiovascular fitness, DEI – daily energy intake, DEXA – dual-energy X-ray absorptiometry, DFI – daily fat intake, ECMR – elevated cardiometabolic risk, FFM – fat-free mass, FFMI – fat-free mass index, FM – fat mass, FMI – fat mass index, FSQ – financial status questionnaire, FTO rs9939609 – Single Nucleotide Polymorphism (SNP) in the fat mass and obesity associated FTO gene, also known as fat gene, G – girls, HAQ – habitual activity questionnaire, HbA1c – glycol haemoglobin, HDL – high density lipoprotein, LBM – lean body mass, LDL – low density lipoprotein, MET – metabolic equivalent of task, MVPA – moderately vigorous physical activity, N – number, NR – not reported, PA – physical activity, PAL – physical activity level, PAQ – physical activity questionnaire, PE – parents' education, QFS – questionnaire concerning financial status, ROC – receiver operating characteristic, SAAT – subcutaneous abdominal adipose tissue, SBP – sedentary behaviour patterns, SES – socioeconomic status, SF – skin folds, ST – sedentary time, VAT – visceral adipose tissue, VATm – visceral adipose tissue mass, VO_2max – maximal oxygen consumption, VPA – vigorous physical activity, WC – waist circumference, WHO – World Health Organization, WHR – waist to hip ratio

Increasing the activity by 1 hour per week resulted in a decline in BMI by 0.13 kg/m^2 [47]. MVPA presented through a regression coefficient indicates that each increase of 100 minutes of MVPA results in BMI reduction by 0.23 kg/m^2 in adolescents aged 10–18 years, independently of sex or ethnicity [43].

Overall sedentary activity and its sub-parts like time spent on watching TV, playing video games, etc. were assumed as independent variables in three studies [40, 44, 47] in order to investigate theirs influence on children anthropometrics. The obtained results indicate that for each additional hour of watching TV, BMI and %FM increased by 0.42 kg/m^2 and 1.14%, respectively ($p < 0.001$) [44]. The presence of the TV in the bedroom and the total TV watching time is related ($p < 0.05$) to higher values of waist circumference ($OR = 1.9–2.1$), %FM ($OR = 2.0–2.5$), and subcutaneous obesity ($OR = 2.1–2.9$), while watching TV ≥ 5 hours a day is associated with high levels of visceral obesity ($OR = 2.0$). Moreover, the presence of TV in the room is bound with elevated cardiometabolic risk (ECMR) ($OR = 2.9$) and high values of triglycerides ($OR = 2.0$) [40]. The risk of obesity was specifically tested in four studies, which indicated that less physically active children were more likely to become obese in adolescence [29, 39, 46, 47].

Conclusions

PAL has a significant impact on the nutritional status of adolescents. The relationship between PAL and nutritional status is inverse, meaning that more active adolescents were less overweight than less active and/or inactive ones and vice versa. Although many studies have shown this connection, PA itself cannot be isolated as a single factor that affects the degree of the nutritional status of adolescents. As it is well known, other factors, such as lifestyle (eating habits, alcohol consumption, cigarettes, often 'nibbling' snacks, the total daily energy intake), socioeconomic status (level of education – both personal and of the parents), racial and ethnicity affiliation, demography and others, also play an important role in weight control.

In addition to the overall PAL, a significant impact on the degree of nutritional status is exerted by the character or intensity of PA. Higher intensity PA has a significantly greater influence on the reduction of body weight and FM, compared with activity of the same duration but moderate intensity. For more beneficial effects on the nutritional and health status of adolescents, PA should be practised every day for more than 1.5 hours, while moderate to vigorous PA should represent more than 45 minutes of all daily PA at last on 3 days per week.

In order not to impair the subjects' health, appropriate dosage is needed in accordance with their requirements and functional capabilities.

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